Report no. 97/EE/55 January 1998

Review of the environmental guidelines prepared by the World Bank for new thermal power plants

---

Final Report submitted to
The World Bank, New Delhi

Energy Environment Interface
Tata Energy Research Institute

Project team

Mr P V Sridharan
Dr Ajay Mathur
Dr Subrato Sinha (Project Co-ordinator)
Mr D S R K Srinivas

Secretarial support
Ms Akhila Rajinder
Mr P Sabari Nath
Mr Sekar

Acknowledgement

This study was sponsored by the World Bank office in Delhi and we gratefully acknowledge the support provided by the World Bank. We would like to take this opportunity to specially thank officers of World Bank, Central Pollution Control Board, Ministry of Environment and Forests, and National Thermal Power Corporation, who provided valuable information and guidance for the study.

Contents

Review of the proposed environmental guidelines prepared by the world bank for new thermal power plants

Introduction

The World Bank has prepared a set of environmental guidelines for new thermal power plants (coal, oil and natural gas based) of generation capacity 50 MW and above. These guidelines spell out the process starting from a set of maximum emission levels acceptable to the world bank group that should be followed in determining the site specific emission guidelines. These guidelines could encompass both controls on the plant as well as other measures perhaps outside the plant that may be necessary to mitigate the impact of the plant on the airshed (or water basin) where it is located. Proposed WB guidelines are designed to protect human health, reduce mass loading to the environment to acceptable levels, achieve emission levels based on commercially proven and widely used technologies, follow the current regulatory and technological trends, be cost effective and promote the use of cleaner fuels and good management practices which increase energy efficiency and productivity. These guidelines assume that the relevant authorities have carried out thorough power sector planning and that the proposed projects represents a least cost solution for increasing power supply, taking into account environmental and social factors.

The Ministry of Environment and Forest (MoEF), Govt. of India, has promulgated environmental guidelines for thermal power plants which includes siting criteria, environmental impact statement (EIS) and environmental management. Central Pollution Control Board (CPCB) has also prescribed set of guidelines for permissible flue gas emission and liquid effluents for thermal power plants using coal, oil and natural gas fuel. CPCB has also notified revised national ambient air quality standards (under Air Act, 1981) in 1994 for industrial, residential, rural and other areas, and sensitive areas.

The World Bank (WB) has entrusted the Tata Energy Research Institute (TERI) to review the proposed environmental guidelines prepared by WB and organise a workshop to discuss the implications of these guidelines.

Objectives

The broad objectives of the study are as follows.

1. Expert review of the draft guidelines with special emphasis on technical, economic, and institutional implications of the guideline in the Indian context if implemented
2. Organize a workshop in which the key stakeholders will participate. The aim of the workshop will be to reach a consensus on the Indian position on the environmental guidelines prepared by the World Bank.

Power generation scenario in India

Coal is the major fossil fuel for power generation in India and all utility boilers use pulverised firing system for combustion of coal. Indian coal contains high ash of around 35-42% with

calorific value of 4000 kcal/kg and sulphur content of 0.2-0.8%. The installed capacity of power generation based on fossil fuels is as follows: coal 54000 MW (64%) and natural gas 6500 MW (8%). In future also it is projected that coal will dominate the power generation scenario in the country. Natural gas contains 85% methane and other higher hydrocarbons. Natural gas has Hydrogen Sulphide (H_2S) ranging from 0 to 0.5% and nitrogen content is also low (0.1-0.5%). Therefore, the SO_2 pollution from gas based thermal power plants (TPPs) may not be having any significant impact. It is imperative to maintain a balance between the increasing demands for electric power and acceptable environmental quality which implies a need for the continual upgradation of pollution control management system.

Emission standards/guidelines for thermal power plants

In India, the Central Pollution Control Board (CPCB) has prescribed emission standards for particulate matter and gaseous pollutants from TPPs. The existing Indian standards and the proposed WB standards are given in Table 1.

Particulate matter

In India, the Central Pollution Control Board (CPCB) has prescribed emission standards for particulate matter which should not exceed 150 mg/m^3 for power generation units of capacity of above 200 MW and 350 mg/m^3 for units less than 200 MW. These standards are based on Indian coal characteristics, meteorological condition, existing flue gas concentration level, control technology.

The existing standards are much higher than the proposed World Bank standards of 50 mg/m^3 for particulate matter. Alternatively, WB guidelines propose that particulate removal efficiency should be designed for 99.9% if 50 mg/m3 is not achievable and operated at least at 99.5% efficiency.

Control measures

There are two globally acceptable technologies for control of the particulate matter (PM) namely electrostatic precipitators (ESP) and bag filters using fabric filter which can offer over 99.8% reduction in particulate emission. The basic criteria for selection of control systems from pollution point of view is the desired level of control needed. The choice of technology depends on resistivity of the ash which depends on fly ash composition and sulphur content of the coal, and operational factors. The commercially proven indigenous ESP's are being used in all the coal based thermal power plants. Indian coal, having an ash content of 35-45%, the ESP efficiency of 99.7% and more is required for meeting the standard of 150 mg/m^3. While thermal power plants in India are commonly using ESP which is less expensive to install and operate but bag filters are the most efficient, particularly while dealing with

Table 1. Indian emission standards and proposed WB emission guidelines for thermal power plants

Parameters	Indian emission standards		WB proposed emission guidelines		
	Capacity	Standards	Standards, mg/m^3	Control options	Main concerns
Particulate Matter	Less than 200/210 MW	350 mg/Nm^3	.50	: Existing technologies (ESP or bag houses) to achieve emission below 50 mg/m^3	Fine particulate: PM_{10} and $PM_{2.5}$
	200/210 MW and above	150 mg/Nm^3	:If it is not achievable, 99 9% removal efficiency for all the plants in airsheds with good air quality	:Coal cleaning to reduce mass loadings and improve boiler efficiency and reduce boiler maintenance	
Sulphur Di Oxide (SO_2)	Less than 200 MW	$H = 14 (Q)^{0.8}$ meters, Q = Emission rate of SO_2 in kg/h	:2000 : Maximum level 0.2 tpd per MW upto 500 MW plus	: Use of gas or low sulphur fuels : Furnace sorbent injection (30-60% removal)	:Local impacts of SO_2 and sulphates on health : Long range transport-acidification and visibility
	200 MW and less than 500 MW	220 m stack height	0.1 tpd per MW for each additional MW over 500 MW,	: Dust injection, dry or wet scrubbers (upto 95% removal), or fluidized bed combustion (upto 95% removal)	
	500 MW and above	275 m stack height	but not more than 500 TPD for any plant		

Parameters	Indian emission standards			WB proposed emission guidelines		
	Capacity	Fuels	Standard, ppm	Standards, mg/m³	Control options	Main concerns
Nitrogen Oxides (NOx)	All Existing units	Natural gas/ Naphtha	150 at 15% excess oxygen	:750 (365 ppm) (Coal) :460 (225 ppm) (Oil) :320 (155 ppm) (Gas)	: Low Nox burners with or without other combustion modifications : Reburning, water/steam injection : Selective catalytic or non catalytic reduction	: Contribution to creation of ground level ozone, acidification and visibility impacts
	New Units (effective from 1.1.1998) 400 MW and above	Natural gas Naphtha	50 100			
	100-400 MW	Natural gas Naphtha	75 100			
	<100 MW	Natural gas Naphtha	100			

Note: The range of control of SO2 is greater because of large differences in the sulphur content of different fuels and in control costs. In general, for low sulphur (<1%S), high calorific fuels, specific control may not be required. Coal cleaning (when feasible), sorbent injection or fluidized bed combustion may be adequate for medium sulphur fuels (1-3%S). FGD may be considered for high sulphur fuels (>3% S). The technology choice depends on a benefit cost analysis of the environmental performance for different fuels and the cost of controls.

smaller particulate and insensitive to ash resistivity, inlet particulate concentration and changes in the flue gas flow rate. However, flue gas with acid or alkaline presence reduce bag house life, and hygroscopic material and tarry components in the ash can lead to bag house filter plugging.

The choice of advance control technology is governed by the coal quality (particularly its high ash and silica content and low sulphur content) and operating practices. The more robust design and operational characteristics of ESPs, along with their lower O & M costs (as compared to baghouse filters) suggests that they are the preferred particulate control technology to meet emission standards of upto 100 mg/m^3, since there is a relatively small cost difference between ESPs and baghouse filters upto this emission limit. Figures 1 and 2 show the capital and levelized cost estimates for ESPs and baghouse filters. The figure indicates that for high-resistivity coals, ESPs are the most cost effective option for emission limits higher than 120 mg/m^3. Pulse jet baghouse filters are more economical for lower emission limits, but have high O & M costs. However, to achieve emission limits of 50 mg/m^3 or less, both the levelized and the capital costs of ESPs are at least 20% more than that of pulse jet baghouses. A new high- efficiency ESP could cost as much as $90/kW. However, lack of experience in bag house operation and maintenance in India suggests that a long learning process may be inevitable if the adoption of this technology is required to meet future standards.

Using washed coal in boiler is an important control option for particulate matter. CPCB has notified the use of washed coal of 34% ash for coal based TPPs located beyond 1000 km from pit head and located in urban, sensitive and critically polluted areas irrespective of their distance from pit head, effective from 1st June 2001.

Comments

In view of the rapid industrialization, and keeping cumulative effects of the different activities in mind, improvement of existing ESP may be the viable options where adequate and appropriate space is available. These improvements includes increasing plate area, widening plant spacing, and providing flue gas conditioning through the addition of moisture, SO_3 or NH_3 and retrofitting technology. Similarly, there is a lack of experience in operation and maintenance of bag house in India. But, bag house would be the most cost effective solution for stipulated WB standard of 50 mg/m3.

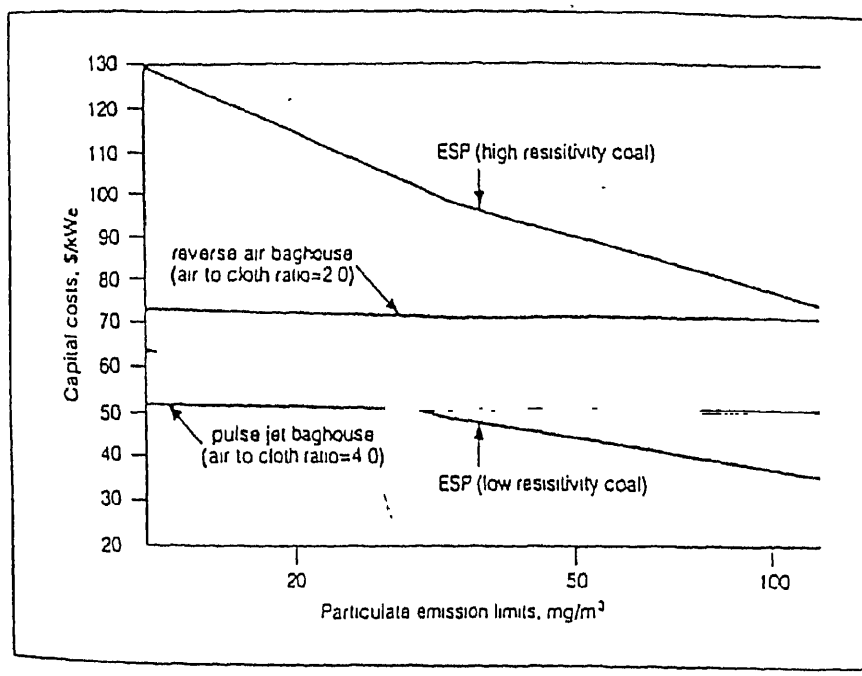

Figure 1. Capital cost per kW installed for ESPs and baghouse filters [10].

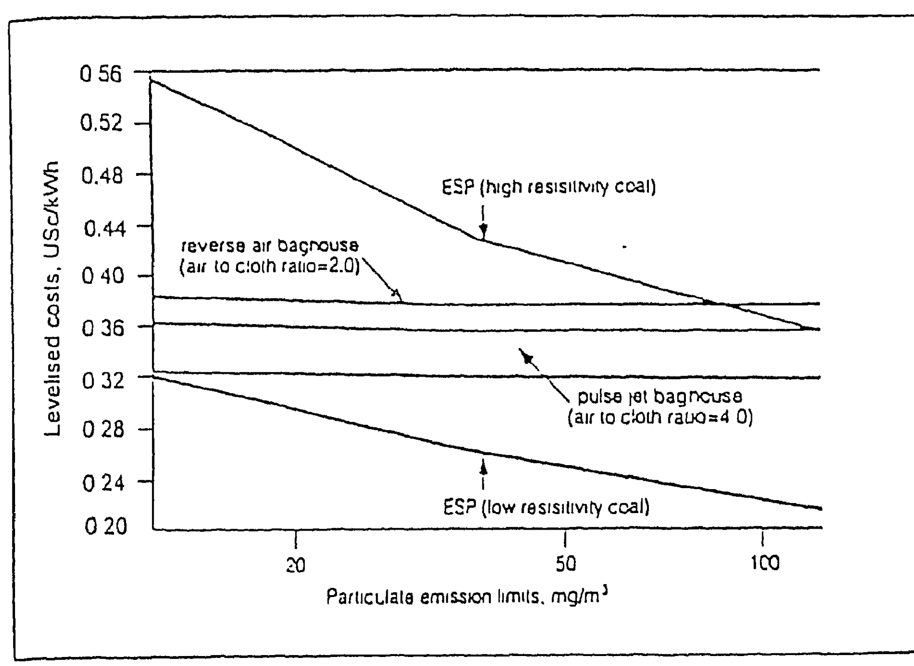

Figure 2 Levelized cost per kWh of electricity produced for ESPs and baghouse filters

Sulphur dioxide (SO_2)

Indian coal, in general have low sulphur content. The typical SO_2 emission from coal based power plants are estimated to be 1250 mg/m^3. Emission of SO_2 from existing gas based power plants was found to be varying between 2.4 to 58.8 mg/m^3. Therefore, CPCB has not yet fixed any emission standards for SO_2, but has suggested to monitor SO_2 emission from the stack height. CPCB has prescribed stack height for various capacity power generation namely 275 m for 500 MW and above, 220 m for 200 MW, 500 MW and for units < 200 MW, the stack height is goverened by the formula $H = 14(Q)^{0.8}$ metres. However, when the power plant uses heavy distillates as fuel, having high sulphur content varying from 1-2% or HSD having sulphur content around 1%, stack height of the plant should be higher and be governed by the formula $H=14\ (Q)^{0.3}$ where Q is the emission rate of SO_2 in kg/hr as prescribed by CPCB.

The WB has prescribed emission standard of 2000 mg/m^3 for SO_2. It also stated that the maximum permissible emission level would be 0.2 tonne per day per MW upto 500 MW and 0.1 tpd per MW for each additional MW over 500 MW but mot more than 500 tpd for any plant.

Control measures

In general, as proposed in WB guidelines, for low sulphur (<1%S) and high calorific value fuels, specific control may not be required. Coal cleaning (when feasible), sorbent injection or fluidised bed combustion may be adequate for medium sulphur fuels (1-3% S). FGD may be considered for high sulphur fuels (>3% S). Choice depends on factors like cost, operating characteristics, and quality of coal.

Comments

The existing SO_2 emission level in India is not expected to lead to major increase in ambient SO_2 concentration. But, with further industrialization in India and increase in power generation, local impacts of SO_2 and sulphate on health and long range transport-acidification and visibility, SO_2 emission will also be an important issue and concern in the country. At the moment, the typical SO_2 emission levels for thermal power plants in India are lower than the recommended WB guidelines.

Oxides of nitrogen

India does not have any NO_X emission limits for coal based thermal power generation. The typical emission from boiler are about 650 ppm. But over the last few years, burner with emission of less than 400 ppm have been introduced. CPCB has prescribed standards for NOx emission for natural gas and naptha based thermal power plants. For existing natural gas and naptha based power plants, the prescribed NOx emission standards is 150 ppm at 15% excess

oxygen. For new plants (effective from 1.1.1998) of capacity 400 MW and above, 100-400 MW and less than 100 MW, the proposed standards for natural gas and naptha are 50 & 100, 75 & 100 and 100 ppm respectively (Table 1). The standards were set based on existing technology and so far achievable emission level for different fuel based power plants. The proposed WB emission standards for NOx is 750 mg/m^3 (365ppm), 460 mg/m3 (225 ppm) and 320 mg/m3 (155 ppm) for coal, oil and natural gas based power plants respectively.

Control measures

Two types of control system namely low NO_X burner (LNB) and off stoichiometric combustion based on combustion modification are generally used.Tangentially fired boiler generates less NO_X than the front wall fired boilers. High amount of exhaust air is used (100-300%) to control temperature thus reducing NO_X emission. Reduction of NO_X using LNB ranges between 30-50%. In off stoichiometric combustion, oxygen content in the furnace is regulated to reduce the fuel NO_X and some of the thermal NO_X reduction is possible upto 30%. Further reductions can be achieved only by treating the flue gas to reduce NO_x to N_2. These reduction strategies could be based on Selective Non-catalytic Reduction (SNCR) or on Selective Catalytic Reduction (SCR). The combustion modification and the reduction technologies together can achieve upto 95% reduction in NO_x emissions. Combustion modifications, such as LNB and OFA, are the most cost effective interventions but can reduce emissions only upto 60%. They also have low operation & maintenance costs. On the other hand, both the capital and O & M costs for SCR are very high, and variable costs for SCR can represent upto 50% of the total levelized cost. The air to fuel ratio is reported to be 1:5 to 1:8 in India. The WB recommend control options are low Nox burners with or without other combustion modifications, reburning, water/steam injection and selective catalytic or non catalytic reduction.

Comments

NOx has been recognized as one of the major pollutants of power generation. NOx like SO_2 in responsible for acid rain. NO_X also take part in number of chemical reactions with hydrocarbon present in urban air to produce toxic pollutants like ground level ozone. At present, emission guidelines prescribed for Nox in India is even more stringent than the proposed WB guidelines.

Water

CPCB has prescribed a set of guidelines for effluent discharge from various sources namely condenser cooling water, boiler blowdown, cooling tower blowdown, ash pond effluent from thermal power plants as given in Table 2. For open cooling water cycle, the standard prescribed is that the difference between the temperature at the intake and the temperature at the outflow to the lake or river should not be more that 5^0 C. However, for closed CW system (water cooling towers) there is no restriction. All the effluent must be neutralized and treated before discharge into waterways or drains. The temperature of discharge water was set keeping into consideration the higher ambient temperature in India.

The WB has set effluent levels for different parameters (Table 3) which should be achieved daily without dilution. Temperature increase should not be more than 3^0 C within 100 m from the point of discharge. Total suspended solids (TSS) have been set at 50 mg/l against 100 mg/l prescribed by CPCB for thermal power plants. In view of the very high ash content in Indian coal, and the fact that cenosphere in ash contribute to the formation of suspended solids, the standard for suspended solids was kept higher.

Table 2. Effluent Standards for Thermal Power Stations

Source	Parameter	Maximum limiting concentration milligram per liter (except for pH and temperature)
Condenser cooling water (once through cooling system)	pH	6.5-8.5
	Temperature	Not more than 5°C higher than the intake water temperature
	Free available chlorine	0 5
Boiler blowdowns	Suspended solids	100
	Oil and grease	20
	Copper (total)	1.0
	Iron (total)	1.0
Cooling tower blowdowns	Free available chlorine	0.5
	Zinc	1.0
	Chromium (total)	0.2
	Phosphate	5.0
	Other corrosion inhibiting material	Limit to be established on case by case basis by Central Board in case of Union Territories and State Board in case of States
Ash pond effluent	pH	6.5-8.5
	Suspended solids	100
	Oil and grease	20

Table 3. WB proposed effluent levels for TPPs

Parameters	Maximum level
pH	6-9
Total Suspended Solids	50 mg/l
Oil and grease	10 mg/l
Total Residual Chlorine	0.2 mg/l
Chromium (total)	0.5 mg/l
Copper	0.5 mg/l
Iron	1.0 mg/l
Zine	1.0 mg/l
Temperature increase	less than or equal to 3°C (100 m from the point of discharge)

Noise

At present, there are no noise standards prescribed in India seperately for thermal power plants. But CPCB has notified ambient noise standards for industrial, commercial, residential, silence areas (Table 4). The existing or proposed power plants should not exceed the standards prescribed for industrial area of 75 and 70 dBA for day and night period respectively. WB has also proposed ambient noise levels for receptors namely industrial/commercial of 70 and 70 dBA for day and night period respectively as presented in Table 5. Noise abatement measures should achieve the above noise levels, measured at noise receptors located outside the project property boundary, with a maximum increase in the existing ambient level of Leq 3 dBA where the existing ambient level exceeds Leq 45 dBA. It was observed from few case studies in India that there is a increase of minimum Leq 6-10 dBA noise level than the background due to setting up of power plants. It needs abatement measures at sources namely enclosures, absorbing materials etc and transmission paths namely green belts & other barriers to keep the noise levels within the WB prescribed standards.

Table 4. CPCB prescribed ambient noise quality standards

Area	Category of area	Limits in decibels, dB (A)	
		Day time	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Note:
1. Day time is defined from 6 a.m. to 9 p.m.
2. Night time is defined from 9 p.m. to 6 a.m.
3. Silence zone is defined as areas upto 100 m around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the competent authority. Use of vehicular horns, loudspeakers and bursting of crackers are to be banned in these zones.

Table 5. WB proposed ambient noise level

Receptor	Maximum allowable Leq (hourly), in dB(A)	
	Day time (7:00-22:00)	Night time (22:00-7:00)
Residential, institutional, educational	55	45
Industrial, Commercial	70	70

Note: Noise abatement measures should achieve the above noise levels, measured at noise receptors located outside the project property boundary, with a maximum increase in the existing ambient level of Leq 3 dB(A) where the existing ambient level exceeds Leq 45 dB(A).

Airshed definition and management

WB guidelines have introduced the concept of airshed of good, moderate and poor quality based on the concentration level of PM10 (particulate less than 10 um in size), TSP (total suspended particulate) and SO2 (sulphur dioxide) (as defined in Table 6) , which would be the major guiding factors for selecting sites for power plants. An airshed will be classified as moderate airshed when annual mean value of PM10 and/or SO2 exceeds 50 μg/m3 (or 80 μg/m3 for TSP) or the 98 percentile of 24 hour mean values of PM10 and SO2 for the airshed over a period of a year exceeds 150 μg/m3 (or 230 $\mu g/m^3$ for TSP). The airshed will be treated as poor when the annual mean value of PM10 and $\mu g/m^3$ or SO2 is more than twice the annual trigger value for the airshed with moderate air quality or the 95 percentile of 24 hour mean value of PM10 and or SO2 for the airshed over a period of a year exceeds the

trigger value for peak exposure levels in an airahed with moderate air quality. The airshed will be taken to refer to the local area around the plant whose ambient air quality is directly affected by emission from the plant. The size of the relevant local airshed will depend upon plant characteristics (such as stack height) as well as local meteorological conditions and topography.

In India, there are national ambient air quality standards for SO_2, NO_x, SPM, RPM (PM_{10}), Pb and CO, prescribed for industrial, residential, rural& other and sensitive areas as presented in Table 7. CPCB has prescribed the 24 hours and annual average standards of 150 & 120 µg/m3, 100 & 60 µg/m3 and 75 & 50 µg/m3 for PM_{10} for industrial, residential\rural & other, and sensitive areas respectively. The standard was set based on meteorological condition, topography, existing levels, concentration levels, population, and other activities.

Besides these defined areas, CPCB has identified 22 polluted areas in the country based on existing activities, pollution load & levels and population exposure. There is a National Ambient Air Quality Programme to monitor various pollutants namely SPM, SO_2, NO_x, etc from 290 stations covering over 90 towns/cities spread over 24 States and 4 Union Territories. The observed data shows a very high level of SPM concentrations. The proposed power plants have to ensure compliance with these standards during setting up of the plant. It is mandatory to carry out a thorough exercise on assessment of expected impact on air, water, land, soil, ecology and socio economic aspects in surrounding 25 km radious of the power plant and provide suitable management actions to ensure safety and health of the people and the environment.

Comments

In Indian condition, where there is an unchecked growth of industrial and other areas, it is extremely important to define the airshed as proposed in WB guidelines. It is equally important to spell out clearly the role of institutions responsible for the management of airshed.

Table 6. Airshed as per WB guidelines

Parameters	Airshed quality	
	Moderate	Poor
Particulate matter less than 10 μm size (PM_{10})	*The annual mean value of PM_{10} exceeds 50 $\mu g/m^3$ Or *The 98th percentile of 24-hr mean values of PM_{10} over a period of a year exceeds 150 $\mu g/m^3$	*The annual mean value of PM_{10} for the airshed is more than twice the annual trigger value for an airshed with moderate air quality. Or *The 95th percentile of 24-hr mean values of PM_{10} over a period of a year exceeds the trigger value for peak exposure levels in an air shed with moderate air quality
Total suspended particulate (TSP)	*The annual mean value of TSP exceeds 80 $\mu g/m^3$ Or *The 98th percentile of 24-hr mean values of TSP over a period of a year exceeds 230 $\mu g/m^3$.	
Sulphur di oxide (SO_2)	*The annual mean value of SO_2 exceeds 50 $\mu g/m^3$ *The 98th percentile of 24-hr mean values of SO_2 over a period of a year exceeds 150 $\mu g/m^3$.	*The annual mean value of SO_2 for the airshed is more than twice the annual trigger value for an airshed with moderate air quality. Or *The 95th percentile of 24-hr mean values of SO_2 over a period of a year exceeds the trigger value for peak exposure levels in an air shed with moderate air quality

Note: The airshed will be taken to refer to the local area around the plant whose ambient air quality is directly affected by emission from the plant. The size of the relevant local airshed will depend upon plant characteristics (such as stack height) as well as local meteorological conditions and topography. In some cases, airsheds are defined in legislation or by the relevant environmental authorities. If not, the EA should clearly define the airshed on the basis of consultations with those responsible for local environmental management.

Table 7. National ambient air quality standards (India)

Pollutant	Time weight average	Concentration in ambient air: Industrial Area	Residential rural & other	Sensitive area	Method of measurement
1	2	3	4	5	6
Sulphur Dioxide (SO_2)	Annual average*	80 $\mu g/m^3$	60 $\mu g/m^3$	15 $\mu g/m^3$	1. Improved West and Gaeke method 2. Ultraviolet fluorescence
	24 hours**	120 $\mu g/m^3$	80 $\mu g/m^3$	30 $\mu g/m^3$	
Oxides of Nitrogen as NO_2	Annual average*	80 $\mu g/m^3$	60 $\mu g/m^3$	15 $\mu g/m^3$	1. Jacob & Hochheiser modified (Na-Arsenite) Method 2. Gas phase chemiluminescence
	24 hours**	120 $\mu g/m^3$	80 $\mu g/m^3$	30 $\mu g/m^3$	
Suspended particulate matter (SPM)	Annual average*	360 $\mu g/m^3$	140 $\mu g/m^3$	70 $\mu g/m^3$	(Average flow rate not less than 1.1 m^3/minute).
	24 hours**	500 $\mu g/m^3$	200 $\mu g/m^3$	100 $\mu g/m^3$	
Respirable particulate matter (Size less than 10 um) (RPM)	Annual average*	120 $\mu g/m^3$	60 $\mu g/m^3$	50 $\mu g/m^3$	
	24 hours**	150 $\mu g/m^3$	100 $\mu g/m^3$	75 $\mu g/m^3$	
Lead (Pb)	Annual average*	1.0 $\mu g/m^3$	0 75 $\mu g/m^3$	0.50 $\mu g/m^3$	–AAS Method after sampling using EPM 2000 or equivalent filter paper
	24 hours**	1.5 $\mu g/m^3$	1.00 $\mu g/m^3$	0.75 $\mu g/m^3$	
Carbon Monoxide	8 hours**	5.0 $\mu g/m^3$	2.0 $\mu g/m^3$	1.0 $\mu g/m^3$	–Non dispersive infrared spectroscopy
	1 hour	10.0 $\mu g/m^3$	4.0 $\mu g/m^3$	2.0 $\mu g/m^3$	

* Annual Arithmatic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Note:

1. National Ambient Air Quality Standard: The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, ti would be considered adequate reason to institute regular/continuous monitoring and further investigations.
3. The State Government/State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of Notification of National Ambient Air Quality Standards.

Siting criteria for thermal power plants

Ministry of Environment and Forest, Govt of India, has notified certain guidelines for setting up the thermal power plants in the country. Proper setting of thermal power plants can reduce not only the cost of the required pollution control measures but also the total damage these stations would cause to natural and human environment. Due consideration needs to be given to topography, geology, hydrology, meteorology, fuel storage, ash disposal, etc. in the selection of site. Selection of environmentally acceptable sites for TPP would be guided by siting criteria which would cover the following.

* Location of thermal power plants should be avoided within 25 kms of the outer peripheries of the following:
  - Metropolitan cities;
  - National parks and wildlife sanctuaries; and
  - Ecologically sensitive areas like tropical forests. biosphere reserves, National Parks and Sanctuaries, important lakes and coastal areas rich in coral formulations.
* In order to protect the coastal areas above 500 m of HTL a buffer zone of 5 km should be kept free of any TPP.
* The site (chimney) should not fall within the approach funnel of the runway of the nearest airport.
* The site should be at least 500 meters away from the Flood Plain of the Riverine Systems.
* The site should also be at least ½ km away from the highways.
* Location of TPP should be avoided in the vicinity (say 10 km) of places of archaeological, historical, cultural, religious or tourist importance and defense installations.
* The TPP should be surrounded by an exclusion zone of 1.6 km and located on the leeward side of the exclusion zone with respect to the predominant wind direction, Residential/commercial development should be regulated in the exclusion zone on the basis of strict land use zoning.
* No forest or prime agricultural land should be utilized for setting up of TPP, or for ash disposal.

WB has proposed some guidelines for siting of power plants in good, moderate and poor quality air sheds. In airshed with good air quality will be subject to the maximum emission levels specified in the guidelines. Plants less than 500 MW in airsheds with moderate air quality will be subject to the maximum emission levels specified in the draft guidelines provided that the Environmental Assessment shows that the plant will not lead to either the airshed dropping into the category having poor air quality or an increase of more

that 5 μg/m³ in the annual mean level for the entire airshed of the pollutant The limit of a 5 μg/m³ increase in the annual mean of the critical pollutants will apply to the cumulative total impact of all power plants built in the airshed within any 10 years period beginning and after the date at which the guidelines comes into effect. Plants greater than 500 MW in airshed with moderate air quality and all plants in air shed with poor air quality will be subject to site specific requirements that includes offset provisions to ensure that there is no net increase in the total emissions within the airshed of the pollutant or pollutants which is the reason for the airshed being classified as having moderate or poor air quality.

The various recommended offset provisions includes installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed, installation of new or more effective controls at large sources namely district heating or industrial plants in the same airshed, and investment in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers. The monitoring and enforcement of offset provisions would be the responsibility of the appropriate local or national agency responsible for granting and supervision environmental permits. The proposed guidelines suggest that large power plant should not be developed in airshed with moderate or poor air quality. Under the project proposal, project sponsors who do not wish to engage in the negotiations necessary to put together an offset agreement would have the option of moving the location of their plant to some other airshed with good air quality or relying upon an appropriate combination of clean fuels and or controls.

Comments

It is important to have a plan or strategy for regional or state growth. The aim is to identify least cost option for reducing total emission of these pollutants from a region or a state. In appropriate cases, there should be a cost effective strategies as well as legal instruments to protect sensitive ecosystems or to reduce transboundary flows of pollutants. The site specific emission requirements should be consistent with any strategy and applicable legal framework that has been adopted by the government to protect sensitive ecosystem or to reduce transboundary flows of pollutants.

Table 8. Guidelines for siting of plants

Power plant capacity	Airshed category	Environmental assessment & emission requirements
Less than 500 MW	Good air quality	Subject to the maximum emission levels specified in the guidelines including SO_2 emission of 0.2 tpd per MW of capacity (maximum of 100 tpd for 500 MW) and maximum concentration of 2000 mg/m^3.
Greater than equal to 500 MW	Good air quality	Subject to the maximum emission levels specified in the guidelines including SO_2 emission of 0.2 tpd per MW upto 500 MW and 0.1 tpd for each additional capacity over 500 MW.
Less than 500 MW	Moderate air quality	Subject to the maximum emission levels specified in the guidelines provided that the environmental assessment shows that the plant will not lead to either the airshed dropping into category having poor air quality or an increase of more than 5 μg/m^3 in the annual mean level for the entire airshed of the pollutant. If either of these conditions is not satisfied, then lower site specific emission levels should be established. The limit of 5 μg/m^3 increase will apply to the cumulative total impact of all power plants built in the airshed within any 10 years beginning and after the date of the guidelines comes into effect.
Greater than equal to 500MW	Moderate air quality & all plants in airshed with poor air quality	Subject to site specific requirements that includes offset provisions to ensure that no net increase in the total emissions within the airshed of the pollutants which are the reason for the airshed being classified as having moderate or poor air quality. The measures agreed under the offset provisions must be implemented before the power plant comes fully on stream.

Note: Offset provisions includes :
1. Installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed
2. Installation of new or more effective controls at other large sources namely district heating or industrial plants in the same airshed
3. Investment in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers.

Monitoring and enforcement

World Bank has proposed direct measurement of the concentrations of PM_{10}, SO_2 and NOx and heavy metals (where applicable) in samples of flue gases should be regularly performed to validate surrogate monitoring results or for the calibration of the continuous monitor (if used). At least three data points for direct emissions measurements should be based on an hourly rolling average. Continuous monitoring of particulate, SO2 and Nox in the stack exhaust for the new power plants is encouraged to assess the performances of the pollution control system. WB has recommend automatic air quality system for measuring ambient levels of PM_{10}, SO_2 and NOx outside the plant boundary. The pH and temperature of the

wastewater discharge should be monitored on a continuous basis. Level of suspended solids, oil and grease and residual chlorine should be measured daily and heavy metals and other pollutants in waste water discharges should be measured monthly if treatment is provided.

The Central Pollution Control Board in India has notified the schedules for air quality monitoring of various parameters in the National Ambient Air Quality Standards as given in Table 9. CPCB has also recommended the number of monitoring stations for source emission and ambient air quality for thermal power plants as presented in Table 10.

Table 9. Air quality monitoring schedule

Parameters	Period (hours)	Days/week	Measurements/year	Measurement method
SPM	24	2	104	Average flow rate not less than 1.1 $^{m3/min}$
SO_2	24	2	104	Improved West & Gaeke method Ultraviolet fluorescence
NO_x	24	2	104	Jacob & Hochheiser modified method Gas phase Chemiluminescence
RPM (PM_{10})	24	2	104	
Pb	24	2/month	24	AAS method after sampling using EPM 2000 filter paper
Co	8	2/month	24	Non dispersive infrared spectroscopy

Table 10. CPCB recommended monitoring guidelines

Boiler capacity	Ambient air quality monitoring stations	Source emission monitoring
Less than 200 MW	2 stations	Once in 4 weeks
Greater than and including 200 MW	3 stations	Once in 2 weeks
Greater than and including 500 MW	4 stations	Once in 1 week

Note: All the stack gas emission results shall be normalised to 12% CO2 in the flue gas

For monitoring water quality, the enforcement mechanism as laid down by the Central and State Pollution Control Boards sets water quality standards with source specific controls devised for abatement of water pollution. Moreover, each source separately acts as a point source in defining a surface water body system. In other words, the water quality for surface water bodies like tanks and rivers would depend on the efficiency of controls for industry.

CPCB & IS (Indian standard) 2490 has laid down certain minimum effluent discharge standards. Therefore, it is essential to monitor the water quality parameter for the effluents arising out of industrial activities for all these parameters.

The parameters which need to be monitored are covered by the IS specification IS-2490 (part 1)-1981, given in Table 11 of the report. However, the critical parameters would include pH, BOD, COD, TDS, TSS, total hardness, temperature, and Ammoniacal Nitrogen. Methods for determination of these parameters are also given in the Table. The flow rate should be essentially measured at the time of sample collection for the effluent stream.

Table 11. Methods of determination of critical parameters of water, wastewater and monitoring schedule

Parameter	Sampling frequency	Recommended method
pH	Once in a month	Electrometric method
Velocity of flow	Once in a month	Current meter or float method
Dissolved oxygen	Once in a month	Iodometric method
Biochemical Oxygen Demand	Once in a month	Dilution method
Total Coliform	Once in a month	Multiple Tube Dilution Technique
Fecal Coliform	Once in a month	Multiple Tube Dilution Technique
Chloride	Once in a month	Argentometric method
Hardness	Once in a month	EDTA Titrimetric method
Calcium	Once in a month	EDTA Titrimetric method
Sodium	Once in a month	Flame Photometric method
Potassium	Once in a month	Flame Photometric method
Chemical Oxygen Demand	Once in a month	Dichromate reflux method
Solids (TSS, TDS)	Once in a month	Gravimetric method
Turbidity	Once in a month	Nephelometer
Ammoniacal nitrogen	Once in a month	Calorimetry

Comments

The monitoring of ambient environmental quality and source monitoring would be the responsibility of the power plants. Automatic monitor for ambient air quality in the area is not being commonly practised.

Impact Assessment

For WB projects, Environmental Assessment (EA) should be carried out early in the project cycle in order to establish emission guidelines and other measures on a site specific basis for a new thermal power plant or unit of 50 MW or larger. It is important to stress that the results of the environmental assessment are critical to defining many of the design parameters and other assumptions such as location, fuel choice etc. required to develop the detailed specification of the project and must be integrated with economic analysis of the key design options. It is essential that the work of preparing environmental assessment should be initiated during the early stage of project conception and design so that the initial results of the study can feed into subsequent stages of project development. It is acceptable to prepare an environmental assessment that considers a small number of options in order to justify a predetermined set of design choices. The various tasks includes Screening, Scoping and terms of reference development, preparing the EA report, EA review and project appraisal, project implementation need to be carryed out as a part of the EA process are given in Figure 3.

The proposed WB EA guidelines emphasize the collection of base line data on ambient concentration of PM_{10} and SO_2 (for oil and coal fired plants) and ground level ozone (and NOx if levels of ambient exposure are thought to be a problem) within a defined airshed encompassing the proposed project; the collection of similar baseline data for critical water quality indicators that might be affected by the plant and the use of appropriate air quality dispersion models to estimate the impact of the project on the ambient concentration of these pollutants

In India, environmental appraisal procedural framework for establishing and operating an industrial unit is given in Figure 4. The Central Government has notified (Dated 10 April, 1997, No. S .O.319. E) that certain category of thermal power plants requiring environmental clearance from the State Government is given in Table 12. In case of pit head thermal power plants, the applicant shall intimate the location of the project site to the State Government while initiating any investigating and surveys. The steps need to be followed as a process of impact assessment are given in Figure 4. Ministry of Environment and Forest (MOEF) amended the EIA notification (S.O.No. 60E) on 10 April, 1997, making the public hearing mandatory for environmental clearance. The public hearing will be conducted by the State Pollution Control Boards before the proposals are sent to the MOEF for obtaining environmental clearance.

Table 12. Category of power plants requiring environmental clearance from the State Government

Type of plant	Capacity
Co-generation captive plants	
Co generation plants	All co-generation plants irrespective of the installed capacities
Captive power plants (both coal and gas/naphtha based) coming up separatively and not along the main industry	Upto 250 MW
Utility projects	
Coal based plants using fluidized bed technology subject to sensitive areas restriction	Upto 500 MW
Coal based power plants using conventional technologies	Upto 250 MW
Ga/naphtha based power plants	Upto 500 MW

Note: Any project proposed to be located within the radious of 25 km boundary of reserved forests, ecologically sensitive area which may include National parks, sanctuaries, biosphere reserves, critically polluted area and within 50 km of inter state boundary shall require environmental clearance from the Central Government.

Summary

Coal is the major fossil fuel for power generation in India and in future it is expected to dominate the power generation scenario in the country. The other promising fuel for power generation would be natural gas and LNG.

The existing emission standards for particulate matter in India are higher (150 mg/m^3) than the proposed World Bank standards of 50 mg/m^3. Alternatively, WB guidelines propose that particulate removal efficiency should be designed for 99.9% if 50 mg/m3 is not achievable and operated at least at 99.5% efficiency. Presently, Electrostatic Static Precipitators (ESP) are the commonly used control devices in all the coal based thermal power plants in India. For Indian coals having ash content of 35-45%, an ESP efficiency of 99.7% is required for meeting the standard of 150 mg/m^3.The more robust design and operational characteristics of ESPs, along with their lower O & M costs (as compared to baghouse filters) suggests that they are the preferred particulate control technology to meet emission standards of upto 100 mg/m^3, since there is a relatively small cost difference between ESPs and baghouse filters upto this emission limit. But, bag house would be the most cost effective solution for stipulated WB standard of 50 mg/m3. However, lack of experience in bag house operation and maintenance in India suggests that a long learning process may be inevitable if the adoption of this technology is required to meet World Bank guidelines.

In general, Indian coal have low sulphur content of 0.2-0.8% and the typical SO_2 emission from coal based power plants are estimated to be 1250 mg/m^3 which is lower than the recommended WB prescribed emission standard of 2000 mg/m^3 for SO_2. CPCB has not provided any emission standards for SO_2, but has suggested to monitor SO_2 emission from the stack height. However, with further industrialization and increase in power generation, local impacts of SO_2 and sulphate on health and long range transport-acidification and visibility, will also be an important issue and concern in India.

India does not have any NO_X emission limits for coal based thermal power generation. But over the last few years, burner with emission of less than 400 ppm have been introduced which can meet the WB proposed emission level for coal based power plants. CPCB has prescribed standards for NOx emission for natural gas and naptha based thermal power plants which is more stringent than the proposed WB guidelines.

CPCB has prescribed a standard of 100 mg/l in effluent discharge for total suspended solids (TSS) against 50 mg/l of WB for thermal power plants. In view of the very high ash content in Indian coal, and cenosphere in ash contribute to the formation of suspended solids, the standard for suspended solids was kept higher. Temperature difference at the intake and the temperature at the outflow to the lake or river should not be more that 5^{0}C as prescribed by CPCB. WB proposed that temperature increase should not be more than 3^{0}C within 100 m from the point of discharge.

WB guidelines have introduced the concept of airshed of good, moderate and poor quality based on the concentration level of PM_{10} (particulate less than 10 um in size), TSP and SO_2 , which would be the major guiding factors for selecting sites for power plants. In India, there are national ambient air quality standards for SO_2, NO_x, SPM, RPM (PM_{10}), Pb and CO and proposed power plants have to ensure compliance with these standards. But in Indian condition, where there is an unchecked growth of industrial and other areas, it is extremely important to define the airshed as proposed in WB guidelines. It is equally important to spell out clearly the role of institutions responsible for the management of airshed

Ministry of Environment and Forest, Govt of India, has notified certain guidelines for siting of the thermal power plants in the country to safeguard ecologically sensitive areas, protected areas, human population, religious and historical places etc. WB has proposed some guidelines for siting of power plants in good, moderate and poor quality air sheds. Plants in moderate air quality will not lead to either the airshed dropping into the category having poor air quality or an increase of more that 5 μg/m^3 in the annual mean level for the entire airshed of the pollutant within any 10 year period from the date on which the guidelines comes into effect. Plants in airshed with poor air quality will be subject to site specific requirements that includes offset provisions to ensure that there is no net increase in the total

emissions within the airshed of the pollutant or pollutants which is the reason for the airshed being classified as having moderate or poor air quality.

The various offset provisions recommended includes installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed, installation of new or more effective controls at large sources namely district heating or industrial plants in the same airshed, and investment in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers. WB has proposed that the monitoring and enforcement of offset provisions would be the responsibility of the appropriate local or national agency responsible for granting and supervision environmental permits. The proposed guidelines suggest that large power plant should not be developed in airshed with moderate or poor air quality. Under the project proposal, project sponsors who do not wish to engage in the negotiations necessary to put together an offset agreement would have the option of moving the location of their plant to some other airshed with good air quality or relying upon an appropriate combination of clean fuels and or controls.

There should be a plan or strategy to identify least cost option for reducing total emission of these pollutants from a region or a state. In appropriate cases, there should be cost effective strategies as well as legal instruments to protect sensitive ecosystems or to reduce transboundary flows of pollutants. The site specific emission requirements should be consistent with any strategy and applicable legal framework that has been adopted by the government to protect sensitive ecosystem or to reduce transboundary flows of pollutants.

World Bank has proposed direct measurement of the concentrations of PM_{10}, SO_2 and NOx and heavy metals (where applicable) in samples of flue gases should be regularly performed to validate surrogate monitoring results or for the calibration of the continuous monitor (if used). WB has also recommended automatic air quality system for measuring ambient levels of PM_{10}, SO_2 and NOx outside the plant boundary. The Central Pollution Control Board in India has notified the schedules for air quality monitoring of various parameters in the National Ambient Air Quality Standards and source emission

For WB projects, Environmental Assessment (EA) should be carried out early in the project cycle in order to establish emission guidelines and other measures on a site specific basis for a new thermal power plant or unit of 50 MW or larger. The various tasks includes screening, scoping and terms of reference development, preparing the EA report, EA review and project appraisal, project implementation need to be carryed out as a part of the EA process.The proposed WB EA guidelines emphasize the collection of base line data on ambient concentration of PM_{10} and SO_2 (for oil and coal fired plants) and ground level ozone (and NOx if levels of ambient exposure are thought to be a problem) within a defined airshed encompassing the proposed project.

In India Environmental Impact Assessment (EIA) for power plants and clearance from the MoEF is mandatory. Recently, the Central Government has delegated this power to the State Government for certain categories of power plants. In addition, the Ministry of Environment and Forest (MoEF) has made public hearing mandatory for environmental clearance. The public hearing will be conducted by the State Pollution Control Boards before the proposals are sent to the MoEF for obtaining environmental clearance.

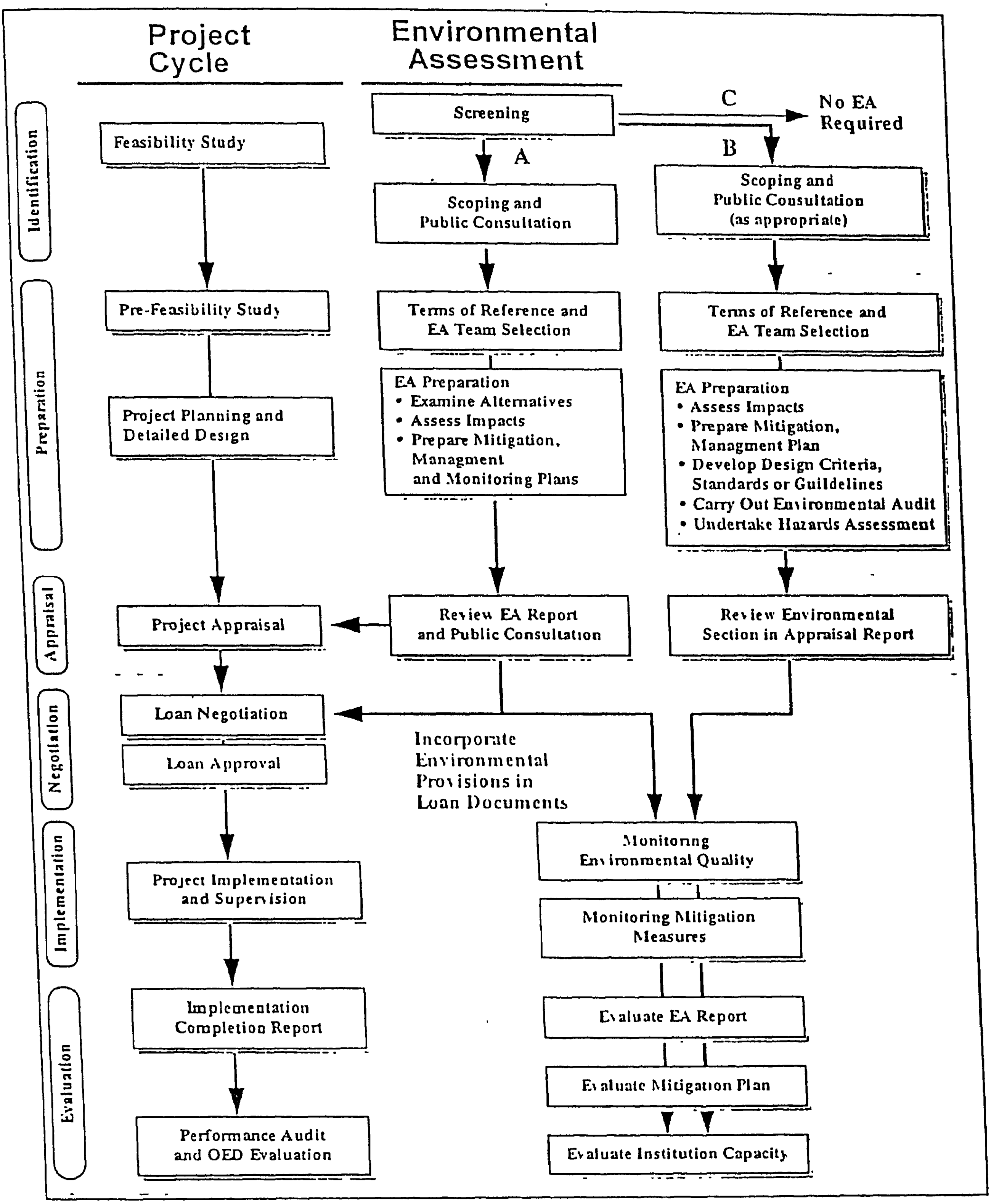

Figure 3. Environmental assessment process of the World Bank

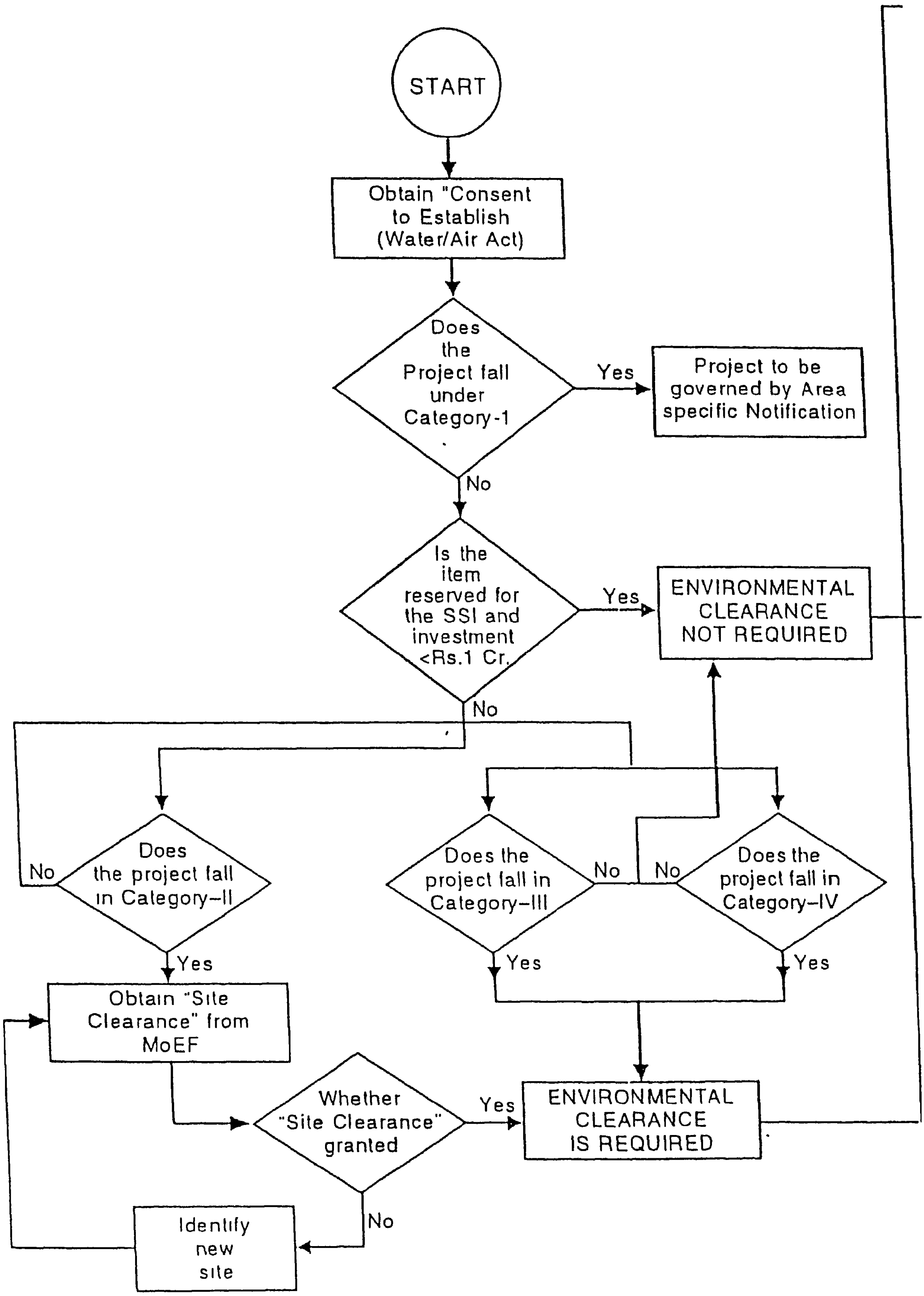

Figure 4. Procedural framework for environmental appraisal in India

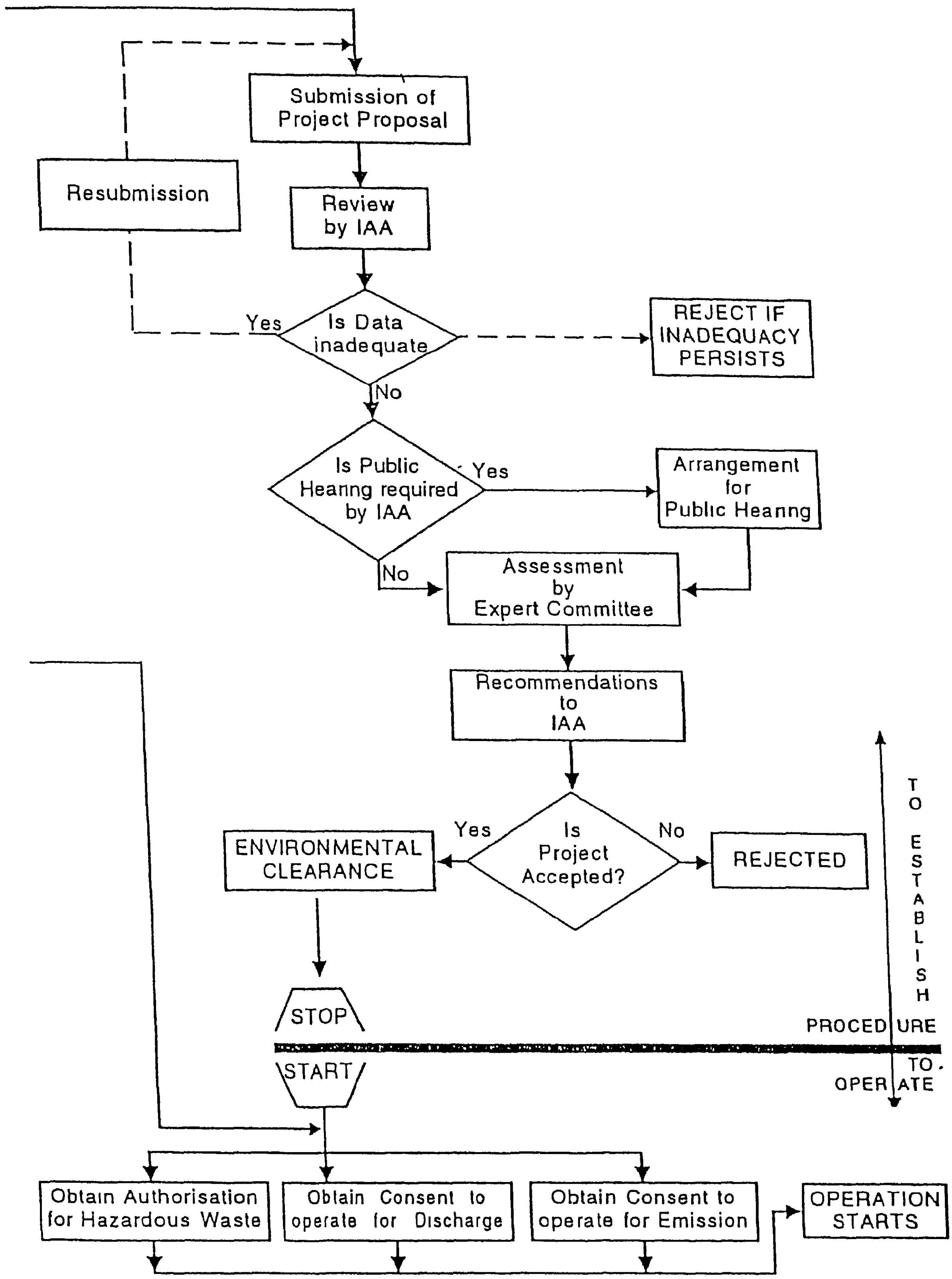

Figure 4. Procedural framework for environmental appraisal in India